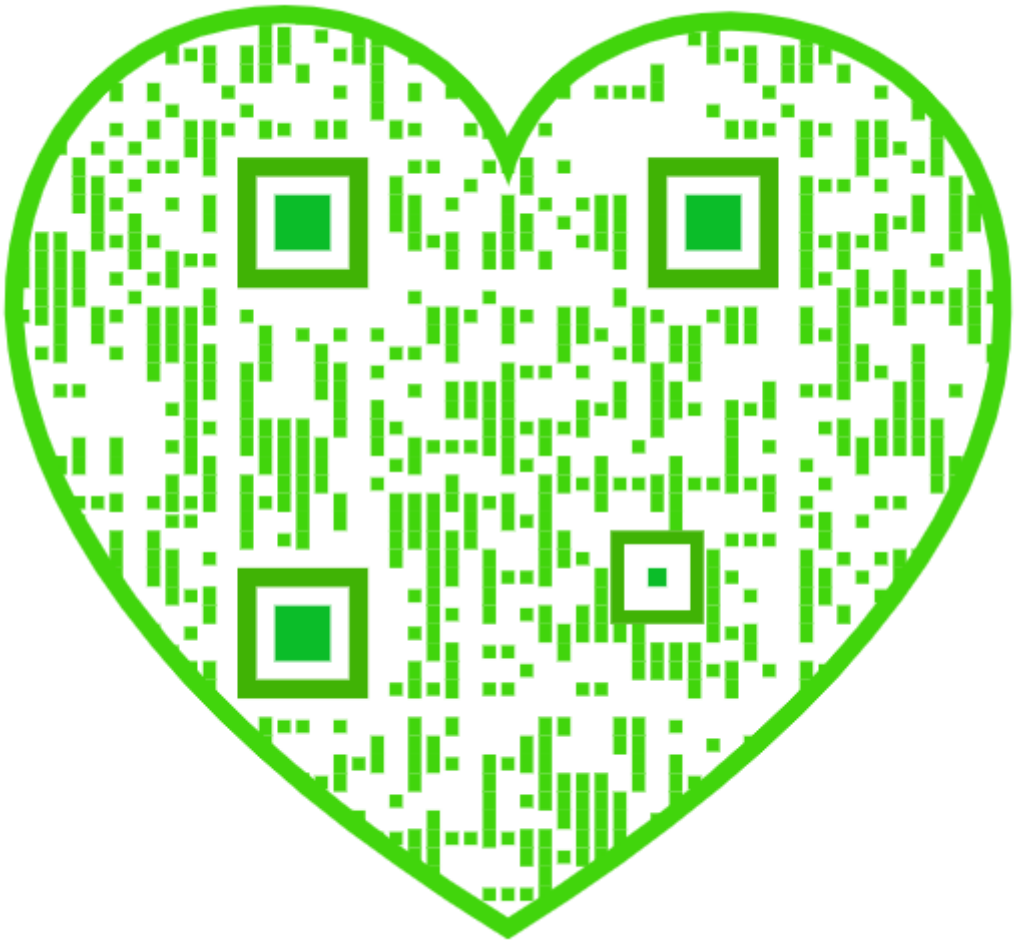

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90.

A Complete System of Sewage Collection and Disposal.

METROPOLITAN SEWAGE

AND

WHAT TO DO WITH IT.

PART I.

IS A SERIES OF PAPERS RELATING TO THE FORMATION AND EXPENDITURE OF THE METROPOLITAN BOARD OF WORKS. THE SEPARATE SYSTEM OF DRAINAGE AND THE MAIN DRAINAGE SYSTEM. THE OPINIONS OF ENGINEERS AND REPORTS OF COMMISSIONERS AS TO THE DIFFICULTY OF DISPOSING OF SEWAGE SLUDGE,

ALSO

AN ACCOUNT OF THE NEW

STOCK BRICK MAKING PROCESS

FOR

UTILIZING SEWAGE SLUDGE,

AND A SCHEME OF

SEWAGE DISPOSAL FOR THE METROPOLIS.

BY

EDWARD MONSON, Assoc. M. Inst. C.E.

AUTHOR OF

"THE ADVANTAGES OF THE SEPARATE SYSTEM OF DRAINAGE."

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INTRODUCTION.

A ROYAL Commission having been appointed to inquire into, and report upon, the system under which sewage is discharged into the Thames by the Metropolitan Board of Works; whether any evil effects result therefrom, and, in that case, what measures can be applied for remedying or preventing the same. The following observations are respectfully submitted, by the author, who has given very much attention to the drainage of the metropolis and the Thames Valley. He published a pamphlet upon the former subject in 1875, which is incorporated in this work, and was one of the engineers who was honoured with instructions from the Lower Thames Valley Main Sewage Board, to prepare a scheme of drainage for their district. He was employed by the Society of Arts to report upon the Metropolitan Sewers; is the inventor of a process for disposing of the sludge of sewage in the manufacture of bricks, has prepared schemes of drainage for various sanitary authorities, and is therefore well acquainted with the subject under consideration.

Any one who has a knowledge of the present state of the Metropolitan Drainage question will at once admit the necessity for the present inquiry, but it does not seem to meet with the entire approbation of the Metropolitan Board of Works, who appear to be in a state of alarm for fear they should be compelled to dispose of their filth in some more decent and scientific manner than at present.

To cast their sewage into the Thames is their pet method of sewage disposal, and if we judge from the discussion now going on they regard every person who thinks differently, as an enemy to their cause. They object to inquiry, and they object to some of the Commissioners, on the ground that they have a previous knowledge of the subject. But has not every eminent engineer a previous knowledge of this subject? If their system be as perfect as they wish us to believe, they need not fear the result of inquiry, but if it will not bear investigation we can readily understand their reason for objecting. However, as the commissioners are men of the highest standing in their profession, we have every confidence in their judgment and their previous knowledge is one of their chief qualifications.

The main drainage, so far as it has been at present carried out, is not a comprehensive system,

because there is no provision for the disposal of the sewage, and no settled scheme of drainage, and because it does not include all those parishes the sewage from which naturally flows into the Thames within the limits of the Metropolitan District. The plan adopted by the Board of Works has been seriously departed from, and flooding has been the result, and to prevent this, works (not included in the said plan) are now in progress, to the amount of about seven hundred thousand pounds. It is a piecemeal, not a comprehensive system of drainage, The Metropolitan Board of Works have no settled scheme, and they are even now partly changing their system. But what right have they to spend our money in this way? As Ratepayers we are entitled to have a definite scheme and to know the probable cost of the work when it is completed, including a system of sewage disposal. The present way of expending money for drainage and the present rate of expenditure is not at all satisfactory, as much of it might have been avoided; and they have exceeded their estimate for main drainage to the extent of £3,400,000.

Again the Board of Works adopted their scheme of drainage one month previous to the repeal of the Section of the Metropolis Local Management Act, which required their plans to be

approved by Her Majesty's Commissioners of Works and Public Buildings, and it would thus appear that they have expended upwards of five-and-a-half millions of money upon a scheme of drainage, the plans for which were never legally approved!

Surely it is quite time there should be some inquiry into and report upon the system under which sewage is discharged into the Thames by the Metropolitan Board of Works, and in the interests of the ratepayers the proceedings in this matter require to be very narrowly watched.

At the present time experiments are being made with floats. The following extract is from *The Builder* 14th October, 1882:—"At the meeting of the Court of Common Council on the 5th inst., Mr. Stoneham asked whether the chairman of the Port Sanitary Committee could give the Court any information as to the progress made by his committee in the matter of the prevention of the pollution of the river Thames. Also whether the chairman could tell the Court what progress had been made by the floats placed in the river at Crossness and Barking, nearly three weeks ago, and how long, judging by the test, it takes for the sewage to reach the sea. Mr. Davis (chairman of the Port of London Sanitary Committee) replied, that they were taking very active steps in this

inquiry, but it was impossible to give any decided answer to the first question. As to the second question, regarding the floats, there was unfortunately some little delay. The floats were not suitably constructed, and they were replaced in his presence on Sunday. This was a continuous work, and if they had lost one tide the experiment would be worth nothing. The float that had reached the furthest point towards the sea was at Shorley Battery, about two miles below Gravesend. Only three floats reached there within from seventeen to nineteen days. There was only one float up the river towards Richmond, which had got as far as Chelsea. One float, by some extraordinary circumstance which had not yet been explained, had never left Barking, but was still in the neighbourhood of the sewage."

The Metropolitan Board of Works were called into existence as a sanitary authority, they took the place of the Metropolitan Commissioners of Sewers, and the work they were appointed to do, was to abate the nuisance arising from sewage being discharged into the Thames; but in this they have utterly failed. Instead of abating the nuisance they have simply transferred it from one place to another, and whereas it was distributed along the Thames over a large area, they have concentrated the sewage all at one point and intensified the nuisance.

The casting of raw sewage into the Thames is directly contrary to the statute. The Metropolitan Board of Works are elected under the Act of 18 and 19 Vic., c. 120. By section 135 of the said Act, the main sewers, then vested in the Commissioners of Sewers for the City of London, and the Metropolitan Commissioners of Sewers, respectively, were vested in them, and they were required to make "such sewers and works as they may think necessary for preventing all or any part of the sewage within the Metropolis from flowing or passing into the River Thames, in or near the Metropolis, and shall cause such sewers and works to be completed on or before the 31st day of December, 1860." And the latter part of the section says, "and may cause the sewage and refuse from such sewers to be sold or disposed of as they may see fit, but so as not to create a nuisance."

Is it not, therefore, as much the duty of the said Board to dispose of the sewage and refuse from the sewers, as it is to make the sewers? But as the case now stands, the river is polluted to a considerable extent, and the navigation impeded by the sewage mud.

Sewage mud consists of the insoluble elements of sewage; the mud and sand washed from the roads; and the chalk and earthy matter precipitated from the water by the refuse soda in the sewage,

which has been used in washing: this being discharged into the river must necessarily silt it up and form shoals.

There is a very considerable amount of deposit in the sewers, if not, why do the Metropolitan Board of Works constantly employ 130 flushers?

As stated hereafter, the Parish of St. George's Hanover Square, removes 450 cubic yards of drift from their sewers alone in the course of a year, but this is a mere trifle compared to the quantity from the whole of the sewers of the metropolis, which is not and cannot be removed, and it goes into the river, and being deposited forms shoals.

The author himself has seen an open ditch from which many cubic yards of earth had been washed down the sewers in consequence of alterations which had been made by the Board of Works. Contractors have been frequently fined for washing slurry down the sewers. Now, where does this go to if not into the river, and if it goes into the river must it not also form mud banks?

The daily flow of sewage into the Thames from the Metropolitan sewers in dry weather is stated to be 120 million gallons, and it is estimated that each gallon contains 100 grains of solid matter, which is equal to 765 tons of solid matter discharged into the Thames daily, or 279,225 tons per annum.

On the part of the Board of Works it is stated

that the sewage cannot be deposited in the bed of the river, and there is evidence to show that it tends to scour rather than to form deposits; and they attempt to prove this by stating that opposite the sewage works the bed of the river has been washed away to the extent of 411,000 cubic yards, since the works were first opened.

That the casting of 280,000 tons of solid matter into the river, along with the sewage should increase its depth and improve the navigation is a new idea and rather hard to believe. But that there should be a scour at the point of discharge is just what one would expect, as the large streams which used to flow into the Thames above bridge have been diverted from their natural course and now pass through the main sewers, and being poured into the river at a new point with increased velocity must of necessity produce a scour; but this does not improve the navigation as the soil thus removed is deposited elsewhere, and the finer particles may be carried to a distance and deposited in slack water.

From a consideration of these facts we should conclude that mud banks would be formed in the Thames from the present system of discharging the metropolitan sewage into the river, and in the discussion of this subject at the Institution of Civil Engineers, February 7th, 1877, Mr. Shelford

stated that "He had had access to the plans of the Thames Conservancy; enlargements of some of which, from a little above the Barking outfall to a little below the southern outfall at Crossness, were now exhibited. It was evident from these that a large deposit of mud had taken place. One of the cross sections had been taken opposite the Southern outfall; another opposite Barking; and the third in Woolwich Reach, opposite Woolwich Pier. Those sections shewed that a huge bank of gelatinous sewage mud had formed opposite Crossness. Its maximum depth was 11 feet, and when there, a couple of men pushed a pole down into it 7 feet without reaching the bottom. Opposite Barking there did not seem to be any great deposit, but there was a considerable divergence from the straight line, and it was possible that the configuration of the shore might account for the absence of deposit. At Woolwich, nearly two miles above Barking, the whole bottom of the river was covered with mud of a considerable depth. The sectional area of the river might be the same as it always had been; but that did not get rid of the fact that a large quantity of solid matter in suspension in the sewage was not carried down to the sea, but was deposited in the river. It was to be accounted for he thought in this way: the suspended matter in sewage was of a gelatinous

floccullent character, however light it might be, it was deposited he believed at slack periods of the tide outside the works, and owing to its sticky nature, it there combined with the sand, and when the flood tide commenced, the mixture of sand and sewage was forced up the river where it became cemented together. It was well known that the tide, at its flood, acted in a wedge like way, and disturbed the bottom. That might account for the fact that sewage sludge was found in considerable quantities above the outfall, notwithstanding that the sewage was only discharged on the ebb tide. In proof of this disturbance he might state that samples of the water had been taken during the flood tide, and they shewed that whereas it was comparatively clear at the top when viewed through a glass bottle, yet if taken 7 or 8 feet below the surface, it was thick, and full of suspended matter. * * * The solid matter in suspension must be deposited somewhere at the nearest point outside the works where still water could be found."

It was also stated in discussion that the soundings of the Thames Conservancy Board shew that previous to the discharge of the Metropolitan Drainage into the river, there was a deep channel on the south side opposite Crossness and extensive anchorage used by colliers, but the anchorage no longer

exists and the deep navigable channel is filled up with sewage mud so that the soundings are reduced from 22 feet to 10 feet and from 22 feet to 11 feet, and the shoal extends far into the centre of the river, and whereas, fish was formerly kept alive at Barking in well boats, they are now obliged to be kept at the mouth of the river in consequence of the sewage.

The metropolis is quite unique in not having a system of sewage disposal, and is the only place in all England where the sanitary authority is now permitted to discharge untreated sewage into running water, and as there is really nothing to prevent its being clarified except the cost, and that would only amount to about £60,000 or £70,000 per annum, besides the cost of Works; even if the refuse were all shot to waste. Is it not therefore quite time that the disgrace attached to this subject should be removed?

The latest idea is to limit the use of the sewers in the city, and complaint has been made that the slurry from asphalte roads is swept down the gullies. As this is polluted water and sewage in every sense of the word, and as the cheapest, best and most efficient way to remove it from the city is by suspension in water, is not such a proceeding in accordance with the principles of sanitary science, and were not the sewers constructed for this

purpose? Are the ratepayers of the City of London to be deprived of the use of their sewers because the Metropolitan Board of Works have neglected to provide proper works for intercepting the sewage from the Thames, and does not this objecting on their part, shew that the sewage does pollute the Thames?—and they know it.

The Metropolitan Board of Works took the place of the Metropolitan Commissioners of Sewers; were called into existence expressly to remove the sewage from the Thames; for this purpose they maintain an expensive establishment; keep a large staff of engineers; and have almost unlimited powers: but yet, with all these advantages, they have utterly failed to do the work for which they were formed, and the Thames is more polluted now than when they first took office.

The Board undoubtedly consists of very able men, but the fact is they have too much to do, and what with gigantic financial operations—colossal improvements—the administration of the building laws—promoting markets and railways—developing electric lighting and building bridges—they have no time to devote to so common a subject as sewage disposal. Under these circumstances, therefore, would it not be well that this matter should be handed over to the City Authorities, who do every thing so promptly, and what they do, they do so well and efficiently.

METROPOLITAN SEWAGE.

SEWAGE TREATMENT AND DISPOSAL OF SLUDGE.

CHAPTER I.

EVENTS LEADING TO THE FORMATION OF THE METROPOLITAN BOARD OF WORKS, AND THE ADOPTION OF THE PRESENT SYSTEM OF DRAINAGE, IN CHRONOLOGICAL ORDER.

Early Sewage Commissions—The First Metropolitan Commission—Jurisdiction extended to all places within 12 miles of St. Paul's—Various Schemes of Drainage—Mr. Phillips' Plan—The 116 Competition Plans—Mr. Foster's Plan—Messrs. Bazalgette and Haywood's Plan—Mr. Ward's Plan on the Separate System recommended by the Secretary of State—The Board's Plan not approved by Commissioners of Works—Referees (Messrs. Galton, Simpson and Blackwell) appointed—Suggestions of Referees—The Board of Works appoint Messrs. Bidder, Hawkesley and Bazalgette to report; who disagree with the suggestions of the Referees—The Plan of Main Drainage never legally approved—The Estimates for the Works insufficient—The Original Estimate—Actual Cost of Works.

FROM the earliest times Commissions of Sewers were issued to the civic authorities, but their jurisdiction at first extended to a distance of only two miles from the city of London; the principal statute was 23 Henry VIII., cap. 5.

On the 17th March, 1807, the

Act, 47 Geo. III., cap. 7, was passed, which extended the jurisdiction of the Commissioners for Westminster, and part of Middlesex, to all the water-courses west of the City of London, extending to, and including, the water-course dividing the parishes of Chelsea and Fulham.

On the 10th July, 1823, a select committee was appointed by the House of Commons to inquire into the laws of sewers.

On the accession of King William IV. in 1830, the Lord Chancellor issued a commission for Westminster and part of Middlesex, and extended the jurisdiction of the Commissioners of Sewers as far up the Thames as Hampton.

In 1834 another select committee of the House of Commons was appointed to inquire into the law of sewers.

From 1843 to 1867 the Lord Chancellor issued seven commissions of sewers.

In December, 1847, the Metropolitan Commissions of Sewers were all united, and this was the first commission whose jurisdiction extended to the whole Metropolis.

In 1848, the 11 and 12 Vic. was passed—"An Act to consolidate and continue in force for two years, and to the end of the next Session of Parliament, the Metropolitan Commission of Sewers," and sec. 1 brings all places within twelve miles of

St. Paul's within the law of sewers. Their jurisdiction was divided into districts or areas draining into the same sewers, and these districts were again divided into "levels," and a different rate was levied in each level.

In 1849, Mr. Phillips, surveyor to the then Commissioners, prepared a plan to drain the metropolis, and in the same year the 12 and 13 Vic. c. 93 was passed—"An Act to amend the Metropolitan Sewers Act," and a second commission was appointed.

In 1850 the Commissioners advertised for plans for draining the metropolis, and 116 schemes were sent in, but nothing was done.

In 1851 a third commission was appointed, and a committee examined the competition plans, and reported against them all. In the same year, Mr. Foster, the engineer of the Commissioners, prepared a plan for the main drainage of the metropolis, which was adopted by the Commissioners, and contracts were taken for part of the works, but they were not executed for want of funds.

In 1851 Mr. Foster died, and in the same year Messrs. Stephenson and Cubitt were appointed consulting engineers.

In 1852 a fourth commission was appointed, and a fifth commission later in the same year.

In 1853 the Great London Drainage Bill was

promoted, and the evidence was ordered to be printed on the 17th June.

On the 24th May, 1853, Mr., now Sir J. W. Bazalgette, the engineer to the Metropolitan Commissioners of Sewers, and Mr. Wm. Haywood, the engineer to the City Commission of Sewers, were associated for the purpose of re-modelling the scheme of the late Mr. Foster for the main drainage of London, so as to accord with the views of the consulting engineers of the Commission, and they presented their report 21st January, 1854; the consulting engineers, Messrs. Stephenson and Cubitt, having previously approved of their plans. This scheme for the drainage of the districts north of the Thames was made to embrace an area of fifty-nine square miles, instead of confining it to the forty square miles proposed by Mr. Foster's plan, it was divided into four districts, northern, middle level, and low level areas, and western division.

1853 and 1854 was an important epoch in the drainage of the metropolis. Cholera was raging at that time, and it was in 1854 that the Commissioners adjourned *sine die* on receiving a letter from the Secretary of State recommending the *separate system of drainage* for the Metropolis, according to a plan prepared by Mr. Ward, and in the same year the Commissioners, having voted the sum of one hundred thousand pounds for drainage, were

recommended by the Secretary of State to suspend all main drainage works for the present; and it appears that at this time everything connected with the main drainage was in a very troubled and disturbed state.

In 1855 a sixth commission was appointed, partly by the Government and partly by election, and on 14th August, 1855, The Metropolis Local Management Act, 18 and 19 Vic., cap. 120 was passed, which came into operation on 1st January, 1856, and sec. 136 required the Metropolitan Board of Works to submit a plan and estimate of the proposed main drainage to the Commissioners of Her Majesty's Works and Public Buildings, and accordingly we see by the Referee's report, ordered to be printed by the House of Commons, 3rd August, 1857, that on the 3rd June, 1856, a plan was submitted to the said Commissioners, and rejected on account of the outfall being contrary to the statute.

On the 5th November, 1856, another plan was submitted to them, and that also was rejected on account of the outfall being so near to the metropolis. Referees were then appointed, and the plans of the Metropolitan Board of Works were submitted to the Referees, Messrs. Galton, Simpson, and Blackwell, for their report, and they reported on 31st July, 1857.

At page 212 of the said report is Mr. Bazalgette's plan for main drainage, adopted by the Metropolitan Board of Works after the passing of the Metropolis Local Management Act, and it is very much like the plan of Mr. Foster; the Metropolitan Boundary is shown as defined by the Act, but the sewers are omitted, as if it were not considered desirable to show too much; the outfall is shown at Rainham, and an alternative line to sea reach. At page 6 the Referees report as follows:—"But we must express our decided opinion that if the River Thames is to be effectually relieved from the sewage which flows into it within the limits of the metropolitan district, it is essential that the scheme of drainage to be adopted should embrace not only the metropolitan districts, but all those outlying districts the drainage from which is included in the same area by the natural features of the ground." And again, at page 11—"The plan upon which the Metropolitan Board of Works propose to drain the London district is briefly as follows:—On the north side of the Thames it is proposed to divide the district into three distinct drainage areas, viz:—high level area, middle level area, the low level and western districts, which include the remainder of the Northern metropolitan area, as well as the portion of the upper valley of the Thames, which is not now included in the metropolitan area, but which is

described by Mr. J. W. Bazalgette, engineer to the Metropolitan Board of Works, as 'prospective area.' The drainage of the Western district is divided into two portions, of which one, consisting of about one-third, is collected in the Counters Creek sewer, and flows into the low level sewer." On Page 12, under the heading, Amount of Sewage provided for, it says:—"The quantity of sewage to be removed for which the plan of the Metropolitan Board of Works provides has been computed by Mr. Bazalgette as follows:—The upper portion of that part of the main valley of the Thames in which the metropolis is situated has been added to the metropolitan districts as 'prospective areas,' and the whole have been divided into sections, of which some have been considered to be urban, and some to be suburban. It has then been estimated that the population of the urban districts will rise to 30,000 per square mile, if they have not already attained that amount; and the suburban districts will attain to a population of 20,000 per square mile."

After the report of the Referees there was a correspondence, and in a letter of the Metropolitan Board of Works, dated October, 1857, they say "That they have no legal power to adopt those recommendations of the Referees, which are directed to the object of intercepting the sewage of extensive districts situate beyond the limits of the metropolis as defined by law."

The Referees say in reply,—"The only districts which we have included besides those termed 'prospective area' in the plan of the Metropolitan Board of Works, are districts, the sewage from which naturally flow into the Thames within the limits of the metropolitan districts. We have already stated at length in our report the arguments in favour of including the drainage of an enlarged area in that of the metropolis. Further consideration of this question strengthens our conviction upon this subject."

The Metropolitan Board of Works appear to have been displeased with the report of the Referees, and on the 23rd November, 1857, appointed Messrs. Bidder, Hawkesley, and Bazalgette to consider the report of the Board on the intercepting of the drainage of the metropolis submitted to the Commissioners of Her Majesty's Works and Public Buildings, and also the report of Messrs. Galton, Simpson, and Blackwell upon the same subject, with instructions to report to the Board as to the best means of carrying out the main drainage of the metropolis.

On the 6th April, 1858, Messrs. Bidder, Hawkesley, and Bazalgette made a very severe report in reply to the Referees, and recommended a plan of drainage which did not carry out the recommendations of the Referees. The Metropo-

litan Board of Works adopted this plan 29th June, 1858, and it was not approved by the Commissioners of Her Majesty's Works and Public Buildings, as required by the Act of 1855. The Act of 21 and 22 Vic., cap. 104, repealing the enactments requiring the approbation of the Commissioners of Her Majesty's Works and Public Buildings, was not passed until 2nd August, 1858. The Metropolitan Board of Works have therefore carried out their scheme of main drainage for the metropolis, and expended upwards of 5 millions of money upon a plan which has never been legally approved.

The estimate of the Metropolitan Board of Works was insufficient, and this was brought to their notice by the Referees, who were appointed to consider the scheme of drainage proposed to be adopted. At page 30 the Referees say:—"In respect to the estimates of the works, we are of opinion that in order to carry into effect a plan which involves many difficult engineering works, and which interferes with many public and private interests, a much larger amount of expenditure will be required than that which has been provided for in Mr. Bazalgette's estimates."

The estimate for main drainage when the Act of Parliament was obtained was only £2,300,000, and that included a separate sewage works for the western district, a considerable length of main

sewers which have not been laid, and the cost of providing for the drainage of parts outside the metropolitan boundary, called 'prospective areas,' which have not yet been carried out. The Referees suggested that the works would cost £5,500,000 but the valuable suggestions of the Referees were not regarded, and the Referees themselves were treated severely, so that, in their report, dated 7th July, 1856, they complain as follows:—"The question under discussion is so important that it is to be lamented that the Metropolitan Board of Works did not refer its consideration to an unbiased tribunal, and we regret that Messrs. Bidder, Hawkesley, and Bazalgette have in their report misrepresented our statements, and have founded upon these misrepresentations arguments adverse to our conclusions."

The works up to the present time have cost £5,000,0000, and about £700,000 additional, for storm overflows is now being spent. In consequence of this blunder in the estimates, all sorts of shifts have been resorted to to make them appear right, and a lot of work has not been carried out that was in the original Parliamentary estimate, in order to keep down the apparent cost.

CHAPTER II.

EXEMPLIFICATION OF THE SEPARATE SYSTEM OF DRAINAGE, AS PROPOSED BY THE GENERAL BOARD OF HEALTH.

What is meant by the term Separate System—The correct Principles of Drainage laid down by General Board of Health—Erroneous views of the Metropolitan Commissioners of Sewers, and their ill effects—The Public Health Act does not extend to London—The Water-closet—The Ash-closet and The Tub Systems—Arguments in favor of the Separate System of Drainage- Surface Water Drainage—Sewage Drainage—Back Drainage—Sewage Gas—Ventilation of Sewers—Results.

HE term "separate system" is frequently misunderstood, or understood in different senses. Some persons understand by this term that the urine is to be separated from the fæces as was suggested by Dr. Thudicum, or as is now proposed by an apparatus connected with a patent earth-closet. And as we have separate mains and separate services for gas and water, so it has been proposed to lay two lines of sewers in every street, one for surface water connected with the gullies and rain-water pipes, and another for the sewage, and that there should be two sets of drains to every house. But such an arrangement would entail much cost in its execution, and be attended with very much difficulty in practice.

The correct principles of town drainage were laid down by the General Board of Health many years since, but they were controverted by the Metropolitan Commissioners of Sewers, who, to a great extent, neutralized the good done by the General Board of Health; and the sewage difficulty, as it is called, has been in a great measure owing to the erroneous views of the said Commissioners, whose example has been followed by other towns. The General Board of Health advocated the separate system, and the removal of excreta by suspension in water. The Metropolitan Commissioners of Sewers, on the other hand, advocated the combined system: the former recommended the use of small glazed earthenware pipes for sewers, the latter recommended large brick sewers; the one recommended that the sewer be laid at the back of the houses, so as to avoid the presence of sewage gas within dwellings; the other laid their sewers under the streets in front of the houses, and beneath each house they carried a long drain from back to front. Up to the present time we have made no advance on the principles of drainage, laid down by the General Board of Health.

As a matter of health, it is desirable that all excretal matter should be at once removed from the neighbourhood of dwellings, and it was proved to demonstration by the General Board of Health,

some years since, that the cheapest, best, and most efficient method of doing this is by suspension in water, but then, on the other hand, the adoption of the water-closet system involves the necessity of clarifying the sewage before turning it into a natural stream or water-course.

The Public Health Act, of 1875, extends to all England—except the metropolis! Why should the metropolis be excepted? Section 17 is as follows: "Nothing in this Act shall authorize any local authority to make or use any sewer, drain, or outfall for the purpose of conveying sewage or filthy water into any natural stream or water-course, or into any canal, pond, or lake, until such sewage or filthy water is freed from all excrementions, or other foul or noxious matter, such as would affect or deteriorate the purity and quality of the water in such stream or water-course, or in such canal, pond, or lake."

Where there is a sufficient water supply the water-closet system is unquestionably far in advance of any other method that has yet been introduced; it is cleanliness itself, independent of the scavenger, and within the control of the household; it is simple, neat, and efficient; the mere pulling of a handle or the turning of a tap being all that is required for effecting the object; it is so great a boon to the country and so great a gain to public

health, that, notwithstanding the apparent loss of manure, the system is never likely to be given up by towns where it has been adopted.

Many new systems have been introduced, but the water-closet is superior to them all; the dry-earth system requires manual and team labour to supply the earth, which renders the product of less value and increases the cost of removal; the ash-closet is simply an ash-pit and privy combined; the tub system is disgusting if not injurious to health, and whilst the water-closet is almost self-acting, these systems require manual labour to replace the receptacles and remove their contents, which is attended with cost; the storage in yards and the removal in carts through the streets are a nuisance; the unnecessary intrusion of strangers into every premises is unpleasant, inconvenient, and indelicate, and during the small hours of the night creates a feeling of insecurity.

There is a very important difference between the sewering of a town and the drainage of a farm, for sewage is water polluted, and contains matter which is so noxious and offensive that covered sewers are necessary for its conveyance, whilst water from land drainage, on the contrary, is clear and fit for use, and being beneficial, wholesome, and pleasant, it is desirable that it should be kept above ground; but this difference is not always kept in view.

As we have seen, it is now compulsory for all towns to purify their sewage before it is turned into rivers and streams. And since the cost of purification will depend upon the quantity of the sewage, it is of the utmost importance that it should be kept in the smallest possible compass consistent with efficiency, and that all land drainage, springs, &c., should be excluded from the sewers. This is called the separate system of drainage, and it is specially applicable to villages, country towns, and to large towns situate on the side of a hill, with open spaces and agricultural land beyond.

Some persons run away with the idea that this system is very costly, but this is a great mistake. There are others who think that efficiency can only be secured by large and costly works, and this also is an error, for in a properly devised scheme the works are not necessarily large or expensive.

The following modification of the separate system of drainage was designed and carried out by the author in 1863 and 1864, at Halstead, in the county of Essex, and is given here as a fair illustration of the system recommended by the General Board of Health.

The plan of the works is that of "pipe drainage on the separate system, and back drainage," the sewers being coterminous with the water supply, sluice valves being placed at the ends of the water

mains, and the whole of the system of sewers being flushed by the discharge of water for cleansing the water mains, or from a large pond at the extremity of the system.

Not aiming at entire separation, the rainfall, streams, and surface water were kept entirely free from sewage, and discharged into the Mill-head: the house drainage or sewage was conveyed in pipe drains to a point beyond the town, to be afterwards dealt with. As the rainfall upon houses and yards is beneficial for flushing, one drain was considered sufficient for each house, and the rainfall in that case was not kept separate from the sewage; but care was taken to exclude from these sewers, as far as possible, all water that was not required for cleansing or for conveying the solids. *The separation, in this case, consisted in keeping the surface water and streams quite free from sewage;* and this is a practical exemplification of the separate system as set forth in this paper. The author considers that the mistake hitherto made has been the attempt to keep sewage free from rainfall—a thing which is impossible. Let us be content if we can keep rainfall free from sewage.

Clean water is almost as important to us as the air we breathe: it is necessary for our domestic wants and to support life; it is required for municipal purposes and to water our roads; it feeds our

streams, rivers, and lakes; it drives our mills, and is essential to our trades and manufactures; it supports fish life, adds beauty to the landscape, and adorns our parks. The consumption of water is daily increasing, whilst, in consequence of the covering in of streams, and the practice of turning clean water into sewers, and sewage which has not been purified into rivers and streams, the supply fit for use is daily decreasing. And again, the supply of water is not now so large as it formerly was, because the rainfall is removed from the land much more quickly than it used to be, and the land being better drained the springs are reduced in quantity. Besides this, the deep-seated springs have been in some cases polluted by dead wells and absorbing wells The storage of water not being sufficiently attended to, is one of the causes of our deficient supply, and another cause is the adoption of the combined system of drainage. If the separate system were universally adopted, and the water which is now wasted recklessly, and inconsiderately, were preserved, there would in some places be abundance as of old, where now we hear constantly increasing complaints of scarcity. It is very poor management to bring water from a distance at the cost of many thousand pounds, when we might have an ample supply at home if it were properly stored and kept free from pollution.

Water is common property, which belongs to and ought to be enjoyed by all, it is, therefore, not only unreasonable and thoughtless to cover in streams and pollute rivers, but we have no right to do so; one community ought not to pollute that which belongs to another community residing lower down the stream. Clean water does no good in sewers, and it is not wanted there except for conveying solids and for flushing the sewers.

Pipe Sewers possess the following advantages: they are self-cleansing and free from deposit; they are comparatively free from sewage gas, and as the sewage gas, if formed, can be readily flushed out, they are conducive to health; they are comparatively free from vermin, for in them rats have no convenience for lodgment; they can be examined at the manholes equally well with brick sewers, and cleaned out with rods, if required; but they require a sufficient supply of water; and flannels, scrubbing-brushes, &c., should be kept out.

Brick Sewers, on the other hand, unless there is a considerable flow of water, are apt to fill up; they then act as gas generators and gas holders, from which the gas cannot be conveniently expelled; for this reason they have been called elongated cesspools and sewers of deposit: they harbour rats. But brick sewers can be examined by means of side entrances and manholes, and men can pass along

them and remove any deposit or obstructions without breaking up the streets. This is certainly an advantage, but obstructions ought not to happen, and in a properly constructed system of drainage rarely do happen.

Halstead is situate upon two hills, which are separated by the river Colne. It is an agricultural town, but there is a crape manufactory, which employs upwards of 1500 hands. A small quantity of velvet is woven in the town, and a great number of women and children are employed in straw-plaiting. The river is headed up, and drives part of the machinery in Messrs. Courtauld's crape factory, and a flour-mill higher up. Previously to the system of drainage being carried out, the sewage was discharged into the Mill-head in the centre of the town, the watercourses were polluted to a considerable extent, and there was a nuisance from the want of drainage at almost every house.

Surface-water Drainage.

The surface-water drainage included street drainage in most cases, land drainage, storm water, and springs. The watercourses were allowed to flow above ground in their natural channels; because sewage being cut off, it was not necessary to cover them over excepting through the town. They were passed under the streets in separate sewers. The existing sewers being cleaned out, repaired, and

reconstructed when necessary, were for the most part used for this purpose

Back Drainage and Sewage Drains.

Almost entirely new lines of pipe sewer were laid at the backs of the houses for sewer drains, of sufficient capacity to receive the sewage only, which included the rainfall from houses and yards.

The sizes of the pipes were respectively 6, 9, and 12 inches, and a short length of 15 inches. The main sewer was a half-brick barrel, and only two feet in diameter. The sizes of the sewers were calculated according to the squares of the diameters, so that by no possibility could the sewers in the lower part of the town be blown or called upon to do more work than they were capable of. Many of the streets were drained with only 6-inch pipes, and that size was found sufficient.

The system of back drainage combines the greatest degree of efficiency with the greatest degree of economy; and if a pipe should chance to leak, it is into the open air, so that it keeps sewage gas outside the house. Drains under houses ought to be laid with iron pipes, or water tight joints, and ventilated outside the house, as most of the foul smells in houses arise from badly jointed drains being laid beneath the floors, and from the want of ventilation.

Back drainage answers most admirably when it

is placed under the care of the sanitary authority especially if the water supply is under the same direction. But it is of the first importance to the proper working of a system of pipe sewers and back drainage that it be regularly inspected and flushed when required; if applied to a few private house it does not answer at all, for it being no person's duty to keep the main drain open it gets stopped, and notwithstanding that it is a great nuisance, one neighbour will not always allow another to enter upon his premises to unstop it. Besides this, it is not fair to throw upon one person, living at the end house it may be, the expense and trouble of keeping open a sewer which is for the common benefit.

The sewage drains at Halstead were so designed that sewage from the upper part of the town could be applied to the adjacent land by gravitation. The drains were coterminous with the water supply, and laid at an average depth of only five feet. It was at first intended to lay them at a depth of ten feet, but on taking the sections it was found that five feet would be sufficient to drain the lowest floor of every house in the town but one.—The least rate of inclination was 1 in 273.

Great attention was paid to flushing. The main sewer in Head Street, and the greater part of the system was flushed by the pond before mentioned. The lower portion could be flushed from the Mill-head

if required. The branch sewers were flushed by the water mains, which communicated with the sewers in the following manner. Sluice valves were placed at the ends of the mains, and when the sluice valves were raised to cleanse the mains it flushed the sewers. In the neighbourhood of London this water would be discharged upon the surface of the street, washing it away. In other cases it was arranged to flush the sewer, from the hydrants, with the fire-engine hose, and private drains could also be cleansed by the same means.

Manholes and inspection shafts were provided at various places along the lines of sewer and at the junctions of sewers, and the rule was that all house drains should be trapped, but the gullies communicating with the surface-water sewers were not to be trapped.

Sewage Gas and the Ventilation of Sewers.

The author believes the recognised principle to be that the sewer authority shall ventilate the sewers, and the owners ventilate the house drains.

In this system the sewage, from its entry into the sewers to its discharge, continued to flow on so that it had no time to decompose and liberate noxious gases, and the formation of sewage gas was prevented to a considerable extent by keeping the sewers free from deposit, by keeping down the

temperature of the sewers by flushing, and by ventilation.

The sewers were ventilated by means of rain-water pipes, properly jointed, and carried up to the roofs of the houses at places where the gases would not be discharged into the bed-rooms. A few charcoal ventilators were put in, and were useful at the ends of the sewers to mark their terminations. But all kinds of charcoal ventilators with which the author is acquainted are imperfect and troublesome, and he considers that the charcoal obstructs the passage of the gas, and hinders ventilation. To make sure, some persons use a mixture of animal and vegetable charcoal. It is now considered best to have openings in the middle of the street, and allow the sewer gas to escape without obstruction. In some cases the gas is allowed to escape after passing through charcoal placed in the side of the gullies.

The compensation paid to the occupiers was only at the rate of 9*d.* per rod. There was no opposition on the part of the owners to the back drainage, for being less costly, they found it was to their advantage. And there were only two or three claims for owner's compensation. The population of the district was 8,000. The total length of new sewers was 5,900 yards. The total cost only £1,500.

The execution of these works entirely cleansed the Mill-head from sewage, and restored all streams and water-courses to their original state of purity. The water, which would otherwise have been contaminated with sewage, was preserved fit for domestic or manufacturing purposes, and being conveyed to the Mill-head was utilized to supply the river and drive the mill. In estimating the results of this system, the value of the water thus preserved must be taken into account, as also the increased value of the sewage. The back drainage was very cheap and most efficient. A short length of pipe, which had a quick fall, and was not likely to be stopped, sufficed for a connection, and the drains were kept outside the houses, which at the present time is the most approved form of drainage. There was no necessity for long and costly lengths of drain pipes under the floors, which mostly have a slow fall, and are not unfrequently badly laid, and imperfectly jointed, and there was no risk of poisonous gases escaping within the dwellings. The houses being free from sewage gas were, consequently, more healthy and comfortable homes for the working population. The yards were most efficiently cleansed. The pipes, being truly laid and connected with the water mains, were self-cleansing, and on being examined twelve months after the completion of the works they were f rfectly fr

sediment or deposit of any kind. The rainfall from the houses and yards, whilst it did not perceptibly increase the cost of main sewers, was beneficial for flushing the house drains, and the owners were saved the cost and the inhabitants the annoyance of having a second set of private drains in every premises, letting alone the difficulty of obtaining entire separation. The sewage was reduced in bulk, and was, therefore, more constant in quantity, more convenient for treatment, and in its concentrated form more valuable for irrigation. The cost of constructing large and expensive brick sewers and manure tanks was saved.

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CHAPTER III.

THE COMBINED SYSTEM OF DRAINAGE AS ADOPTED BY THE METROPOLITAN BOARD OF WORKS FOR THE DRAINAGE OF THE METROPOLIS.

The term Combined Drainage explained—The reason for adopting the Combined System—The Metropolis North of the Thames—The Eastern District—The Western District—All the Sewage brought to Abbey Mills—The Pumping Stations—Engines and Pumps at Western Station—The Sewers—Ventilators—Side Entrances—The Low Level Sewers are Sewers of Deposit—Formation of Sewer Gas—The mode of Cleansing the Sewers—The Number of Flushers for the Main Sewers; The Westminster District; St. James'; St. George's, Hanover Square—Sanitary Defects.

HE term combined system of drainage, is used here to convey the idea of having one set of sewers for all purposes, constructed to receive not only the sewage but the land drainage and storm-water as well. The term is used as the opposite of the separate system, just described; and it is not meant to convey the idea of combining several towns together for the purpose of drainage, as, for instance, the towns situate in the Lower Thames Valley.

This system appears to have been adopted upon the theory that rain falling upon the streets is as much polluted as sewage, and ought to be treated as such, and this, perhaps, is correct as to a few

main streets, but these are the exception and not the rule, for there are thousands of streets in London in which there is but little traffic and to which this theory does not at all apply.

The whole of the metropolis is drained by this system, but the author in this volume intends to deal only with that part of it which is North of the Thames, and consists of two distinct drainage areas, which, for convenience of reference, we shall call the Eastern and Western districts.

The Eastern district extends from Bow on the East, to Notting Hill and Shoot-up Hill on the West, and is drained by three large main sewers, which pretty nearly follow the contour of the ground, and are called "The North High-Level Sewer," which, running through Hackney, Stoke Newington and Holloway, terminates at Kentish Town. "The Middle-Level Sewer," which, diverging from this at Victoria Park, is carried along Bethnal Green Road, Old Street Road, Oxford Street, to Notting Hill, where it turns off and terminates at Kensal Green. "The Low-Level Sewer" commences at Abbey Mills pumping-station, and is carried across to Limehouse Basin, along Back Road, Royal Mint Street, Lower Thames Street, Cannon Street, to Blackfriars Bridge, along the Thames Embankment to Whitehall, along Victoria Street and Belgrave Place to the Western pumping-station.

The Western district extends from Notting Hill to Shoot-up Hill on the East, to beyond Stamford Brook on the West. It is drained by the Counters Creek Sewer, which pretty nearly follows the line of the creek to the Royal Crescent, from whence there is a branch to Acton. The main line sewer, Western division, commences at the Western pumping-station, and is carried across to Walham Green, along Fulham Common Fields to Hammersmith, and passing under the creek, is continued to Chiswick. Out of this there are branches along the Stamford Brooks.

At present the whole of the sewage from both the Eastern and Western districts is brought to a point at Abbey Mills, and the low-level sewage is lifted to a height of 36 feet into the outfall-sewer, so as to be on the same level as the sewage of the high and mid-level sewers. From this point an embankment has been constructed to near Barking Creek, a distance of four miles, and in this is laid three separate large outfall sewers.

The sewage of the Western district is brought to the Western pumping-station along a sewer 5 feet in diameter, which has a fall of 4 feet to the mile, the invert at the pumping-station being 19 feet below Ordnance Datum. It is lifted 18 feet and discharged into the low-level sewer, along which it flows to Abbey Mills, and is then again lifted 36 feet,

together with the low-level sewage, into the out-fall sewer, and goes on to the works near Barking Creek, where it is discharged into the Thames at the ebb-tide. During the flow of the tide the sewage is stored in a large reservoir, and during a storm the sewage can be, and is, discharged direct into the Thames within the metropolis by means of connections with the river, called storm overflows, and it can be pumped into the river.

There are two pumping-stations, the one at Abbey Mills, which is a very handsome building, in the form of a cross, with a good deal of stone-carving externally, and the interior beautifully decorated; the highly-finished and well-kept steam-engines, eight in number, working sixteen pumps are placed at right angles to each other, two being placed in each bay of the building; the steam-boilers and the whole of the mechanical arrangements are of the highest order. There is a large sewage tank under the floor of the engine-house, from which the sewage is pumped, and gratings or cages are placed across the low-level sewer to intercept anything that would injure the pumps.

The other, the Western pumping-station, is situate in the Grosvenor Road near Chelsea Bridge, adjoining the railway, and was opened on the 5th August, 1875. There are four steam-engines of 85 nominal horse-power, working eight pumps, 5 feet $3\frac{1}{2}$ inches

diameter, and 4 feet stroke. Besides this, in case of a break down, there is an auxiliary engine of 120 horse-power, working two double-action 4 feet pumps and having a 4 feet stroke.

The sewers for the most part are constructed of brick, but some are made of concrete. They are ventilated by means of gratings placed in the centre of the streets, and there are side entrances which are placed under the paths.

The low-level sewers, constructed at a level sufficiently low to pass under the existing outfall sewers, have no available outlet except by pumping. In point of fact they are not sewers at all, but sewage tanks or reservoirs, and hold the sewage supply for pumping. They are the sludge chambers of the metropolis, and receive the filth of the adjoining parishes. They are elongated cesspools, and unquestionably sewers of deposit. Not being in duplicate they are never entirely emptied. The sewage, therefore, becomes putrid and offensive, and the smell is the subject of frequent complaint.

From inquiries as to the extent of the existence of sewers and drains of deposit in the metropolis made by the author for the Society of Arts, and which extended over a period of twelve months, he found that many of the sewers are not self-cleansing, and in proof of this he noticed the fact that a great number of men are required by

the Board of Works and the various vestries to keep the sewers open and in working order. Dr. Liddle, Medical Officer of Health, says, in answer to the questions from the Society of Arts, "That the sewer belonging to the Metropolitan Board is almost always very offensive at the south end of Dock Street and Nightingale Lane, by the London Docks entrance. Some of the main sewers contain a large quantity of deposit, which compels a frequent cleansing of them and the deposit is taken out of the sewer and removed by the aid of carts."

In some cases the old flat-bottomed sewers, originally constructed for surface water, have been utilized for conveyance of sewage, and these as a rule are not self-cleansing, but sewers of deposit, a natural consequence of the sewage being spread over a wide surface and retarded by friction. A flusher says that in some cases the sewer bottom is not regular, and the filth accumulates in the pot-holes to the depth of a foot or eighteen inches, and there have been frequent complaints in the papers.

Some of the smaller sewers belonging to the vestries are not self-cleansing, and being inconvenient to work in and difficult to inspect, they get neglected. In a case of this kind the informant says that when he inspected the sewer it contained upwards of a foot of filth in a state of putrefaction; and without doubt

there are many other places in a similar condition, but it is very difficult to get reliable information. The author has it on good authority that in a certain district at the West End there are sewers of deposit in a very bad state, but the vestry employ no flushers, and the filth is allowed to accumulate from day to day.

Sewers of deposit mean the decomposition of putrid matter, and the constant formation of sewage gas which escapes through the ventilators in the streets, and through any untrapped openings. In consequence of the traps being left off, through the carelessness of servants, it is discharged into dwelling houses, and finds its way into bedrooms through the open joints of the rain water pipes. Again, during a storm, the low level sewers are filled and the sewage heads up. As the sewage rises, the sewage gas becomes more and more concentrated, and if sufficient means of ventilation are not provided, it is forced up the drains and discharged into dwelling houses through the traps.

The Mode of Cleansing the Sewers.

The sewers not being self-cleansing, it is necessary to employ manual labour to keep them open and in working order. So great is the deposit, that for the main sewers alone, 130 men are constantly kept by the Metropolitan Board at this

work, and the sewers for this purpose are divided into six sections, three on either side of the river. The men are called flushers, and are paid 4s. 6d. a day. They are divided into gangs of about five men. To every gang there is a foreman, and to every twenty men there is an inspector. The open sewers are cleaned out about once a year, the other sewers in rotation, and as required. They are flushed by means of a dam board, which fits the sewer, and has a hole in the shape of a V cut in the lower edge. The dam board being fixed, the sewage heads up, and rushing through the aperture stirs up the deposit, and separates the drift from the organic matter which is flushed on, and at length discharged into the Thames. The drift and other inorganic matter is conveyed in barrows to the man-holes, brought to the surface and used in road making, or sold to "jerry builders" for about sixpence a load. My informant says, that "Vestries are not obliged to construct catch-pits, and slosh is frequently forced down the gullies, and into the main sewers to the extent of two or three hundred loads of deposit at a time." As a rule no deodorants are used. Sometimes there is inflammable gas in the sewers, and on more than one occasion, it has been fired by the light which the men carry on their heads when at work, and they have been injured. At

Wandsworth, two flushers were suffocated whilst working in the sewer, owing to a discharge from some chemical works; two gangs of men had previously refused to work in the sewer.

Whilst the main sewers were being constructed by the Metropolitan Board of Works, the various Vestries and District Boards have spent large sums in the construction of self-cleansing sewers of the egg-shaped pattern; they also employ flushers to cleanse the old flat-bottomed sewers.

In the Westminster district five flushers are employed by the District Board, and they work by day; they are expected to keep the sewers clean, and are not paid for overtime. The wages are £1 5s. per week, and two pairs of boots per year. Deodorants are used in special cases. My informant says that "the deposit comes chiefly from the macadam roads. The sewers are mostly egg-shaped, the inverts of the flat-bottomed sewers having been taken out, and the sewers altered by underpinning. The gullies are trapped, and the sewers ventilated in the middle of the roads. The pipe-sewers are kept clean by occasional flushing, and may be called self-cleansing. The sewage never heads up now, and the main drainage is a decided advantage to this district."

In the St. James's district there are about two miles of main line sewers in Oxford Street, Regent

Street, and Piccadilly, and there is a local sewer over the main line sewer. Three flushers are employed by this Vestry; the foreman has 30s. per week, and the others £1; the hours are from six to half-past five o'clock, and, if additional flushing is required, it is done by contract. Many of the sewers in this district are 5 feet 6 inches by 3 feet, the Westminster pattern. Upon the inverts of some of these, a pipe was formerly laid for the conveyance of sewage, but it became silted up, and the surveyor has had all the pipes taken out and the sewers reinstated. The fat and other stuff coming from the clubs consolidates in the sewers, and is a great deal of trouble. There are fourteen miles of sewer, but it is the three miles in the neighbourhood of Piccadilly upon which the men are principally employed, and their work is greatly facilitated by the rats, and by the vagabonds who go down into the sewers to see what they can find. This district is said to be much improved by the main drainage. A table, showing the various sewers, hangs in the surveyor's office.

In the district of St. George's, Hanover Square, the number of flushers employed is six. The wages of the foreman are 25s., and the wages of the men 24s. per week; the hours are from seven to four o'clock. The men work during the day, and it is estimated that they bring to the surface 450 cubic yards of deposit in a year, which is removed at 4s. per cubic

yard; it consists chiefly of drift and macadam. The flushers are not troubled with fat in the sewers. The population reside only during the season. There are about 52 miles of sewer, and, as a rule, they have a good fall, but in Belgravia the fall is bad. The ventilators are in the middle of the streets and the gullies are trapped. The old sewers are of the Westminster pattern, the new ones egg-shaped. The inverts of the old sewers have been taken out and replaced by inverts of the egg-shaped pattern. There are very few pipe sewers in the district.

Sanitary Defects.

The works are defective in not being self-cleansing. It must be a wrong system which requires so much labour to keep the sewers open and in working order, and which depends very much for its efficiency upon manual labour. In the intervals between the visits of the flusher, the sewers must be left to themselves, and a deposit must be constantly forming, and the organic matter constantly decomposing and liberating noxious gases which pollute the air. The flushing may be well done and well looked after, but still, with sewers which are not self-acting, these things must happen. If a system of self-cleansing sewers had been constructed (and all main sewers ought to be self-

cleansing), so many flushers would not be required, the sewage would not have time to decompose, and the formation of sewer gases would, to a considerable extent, be prevented. The washing of the sand out of the sewage by the flushers is a novel and brilliant idea, but this might be accomplished at much less cost. The drift, which finds its way into the sewer, ought to be excluded, and after it has entered the sewer, it might be intercepted by properly constructed catch-pits. The flat-bottomed sewers might be altered so as to be self-cleansing, and inequalities in the sewers might be removed by reconstruction or lining. The decomposition of the sewage might, to a considerable extent, be prevented by a proper deodorant skilfully applied.

CHAPTER IV.

IMPERFECTIONS OF THE METROPOLITAN SYSTEM OF DRAINAGE, AND PROPOSED REMEDIES. THE CAUSE OF FLOODING, AND HOW IT MIGHT BE PREVENTED.

The advantage of having High Level and Mid Level Sewers not turned to account—The Drainage of the Western District not satisfactory—The Original Plans included a separate Sewage Works for this District—The Plans seriously departed from—The Western joined to Eastern District—The cause of Flooding—How Flooding might be prevented—Money wasted to construct Storm Relief Sewers—Will throw System out of harmony—The Cost incurred in consequence of the mistake of the Metropolitan Board of Works—The Systems compared—The Separate System recommended—Extension of the Metropolitan System to the Lower Thames Valley.

HE system for the Eastern district is extremely good in detail, but it is not a comprehensive scheme of drainage and sewage disposal. The idea of having high and mid-level sewers to take such sewage as can be dealt with by gravitation, and a low-level sewer for sewage that requires pumping, is very clever; nothing could be better; but after being cleverly planned for collecting the sewage, the principle being one of distribution, the advantages of this plan for sewage disposal are entirely thrown away by concentrating all of it at one point and at one level at Abbey Mills. The advantage of collecting sewage at a

high level is not turned to account, and there is a want of harmony between the principles of collection and disposal, the former being one of distribution, whilst the latter is one of concentration.

The Western district is not drained in a satisfactory manner. A large portion of it being agricultural land or open ground like Wormwood Scrubbs and Old Oak Common, was admirably adapted for the separate system, but in this case, also, the combined sytem of drainage has been adopted. The streams have been covered over and treated as natural sewers, and the whole of the sewage from this immense area, plus the water from the large streams, including the rainfall and storm water, of the district, are discharged into the low level sewer of the Eastern district, at Grosvenor Road, by pumping.

The Western district requires particular notice as not being connected with the rest of the metropolis for drainage purposes; it was, at first, very properly treated as a separate drainage district, and the original plans adopted by the Metropolitan Board of Works included a sewage works at Sandy End, Fulham, but a serious departure has been made from this scheme. The Western has been tacked on to the Eastern district, and the sewage, which would have been disposed of at Sandy End, is pumped into the low level sewer of the Eastern

district. But what right have streams and storm-water to be admitted into the low level sewers and twice pumped?

The joining together of the Eastern and Western districts is, without doubt, a great blunder, and cannot now be easily rectified. It causes flooding, is very inconvenient in working, and the sewers are not proportioned to the work they have to do. If the Western district had paid for its own works only, it might have been as efficiently drained and considerably less taxed. The Eastern district pays the Metropolitan Board of Works most handsomely for discharging its untreated sewage into the Thames.

If the water were saved, which is now wastefully turned into the sewers, it might perhaps, with suitable arrangements, be utilized for street watering, flushing sewers, &c. It would not then be necessary to abstract water from the Thames for that purpose, and the ratepayers would save the payments which are now made to water companies on that account. The works at Abbey Mills would be more efficient, and the power of the pumps and engines would not be overtaxed. Instead of the present overflows, tumbling bays and weirs, which are all wonderfully clever in their way, the surface-water would flow away in a pure state through the existing channels, and the pumps in dry weather would have comparatively little to do.

Because the sewage in the low level sewers has all to be pumped, it is very necessary that it should be reduced to the least possible quantity, by excluding all streams, rainfall, storm-water, and all the sewage that will flow away by gravitation; and it is desirable that no more sewage should be brought to the pumps than what they are able to lift; but as we have seen this has not been attended to, and the consequence is that a whole district is liable to be flooded by night or by day, "causing great destruction of property, pecuniary loss, and danger to the public health."

The Cause of Flooding.

The flooding from the low level sewer is from two causes—the one in consequence of the storm-water being collected with the sewage, and the other in consequence of the sewage from the Western district, which is not naturally connected for drainage purposes, being improperly tacked on to the Eastern district, so that the storm-water from a large district containing much agricultural land and open spaces, is received into the low level sewer.

The metropolitan sewers are of enormous size, but notwithstanding that they are unnecessarily large for the conveyance of sewage proper, they are totally inadequate to carry off storm-water,

and during a storm, sewage is discharged into the Thames, within the metropolis from the pumping-station and from the various inlets into the Thames, called storm overflows. They are only made sufficiently large to carry off a quarter of an inch in depth of rainfall in 24 hours, but during a thunder-storm the rain falls at the rate of two or three inches per hour, and at times steadily two inches in 24 hours, and then the houses of whole districts are flooded with sewage, and this is just what one would expect from such an arrangement.

The following extract is from the *Builder* of the 8th May, 1874:—

At the meeting of the Court of Common Council, Mr. Deputy Hora asked whether the Metropolitan Board of Works were taking any, and if any, what steps to prevent the serious inundations after rain-storms, causing great destruction of property, pecuniary loss, and danger to the public health. Mr. Deputy Lowman Taylor, in reply, read a letter from Sir Joseph W. Bazalgette, in which he said, "This Board has diminished the extent and frequency of floodings by carrying off through the intercepting sewers rainfall to the amount of a quarter of an inch in depth spread over London in twenty-four hours. But on the 11th instant the rainfall in the East End of London amounted to an inch and a half in one hour, or 150 more times than our intercepting sewers

and pumps could take. Such storms can only be carried off by what are termed 'the storm-overflows,' which discharge by gravity into the river. These must be above the level of low water, and many of the basements connected with them are so deep that when the sewers are full the water flows back into them. This is the great cause of flooding."

How Flooding might be Prevented.

Flooding in the low level sewer, the author conceives, may now be prevented by cutting off the connection between the Eastern and Western districts, which would so reduce the quantity of sewage that the pumps would be able to lift the remainder, and by cutting off all storm-water, which would not be difficult so far as the low level sewer is concerned, or by lowering the lift of 40 feet and using syphon pumps, so that the sewage should not be lifted to a greater height than the actual difference of level between the water in the sewer and the water in the Thames, and by constructing a low level gravitation sewer at the lowest possible level, so as not only to prevent flooding from storm-water, but to save a great deal of unnecessary pumping.

Flooding might have been prevented if the principle of keeping the streams free from sewage and allowing the clean water to flow into the Thames along the natural channels had been

adopted, as the ancient water ways were sufficient for that purpose except in a few instances, until they were stopped up or altered by the Metropolitan Board of Works. This modification of the separate system of drainage, would have saved us—the ratepayers—a considerable amount of money in the first cost of constructing the works. Besides this the Metropolitan Board of Works are now actually expending £700,000 in the construction of what they call storm relief sewers, the greater part of this expense being obliged to be incurred in consequence of disregarding the advice of the General Board of Health, and adopting a wrong system of drainage. The constructing of these storm relief sewers, will throw the system of drainage out of harmony, and the sewers will not now be of a size proportioned to the work they will have to do.

The metropolis is a very big place and the system of main drainage a very big thing—quite American in its way; with big pumps and engines, and a big lot of sewage, which when discharged into the Thames, is a big nuisance. The idea of concentrating all the sewage at one point is a big blunder; and the flooding of the low-lying district during a storm is a big blot which might have been avoided.

The Metropolitan Board of Works have made a great mistake in adopting the combined system

of drainage as they are now unable to deal with the sewage on account of its enormous bulk, without incurring a great deal of unnecessary expense.

The works for a combined system of drainage are very expensive, there are the costs of sewers and tanks, which must be of enormous size to take in the storm-water, and, if pumping be resorted to, there is the cost of steam-engines and pumps, which must be proportionately large to do the extra work. Then there are the annual cost of pumping, and the extra outlay for chemicals, chemical treatment, filtration and utilization, or some of them. In short, combined drainage means: payment for unnecessary engine power, unnecessary storage room, unnecessary cost for sewers, unnecessary cost for works, and unnecessary cost for labour. But when all this is done, and, notwithstanding all the extra cost and trouble, the works are not so efficient as those of the separate system, which is better in every respect. The works are cheaper to construct, only a small pipe sewer being required for the one, where a large brick sewer is demanded for the other, and it is more economical in working. The sewage in the separate system being concentrated, is comparatively small in quantity, and can be conveniently treated or utilized at small expense, whilst in the combined system it is so much diluted and so large in quantity as to be costly, troublesome,

and difficult to utilize, to treat, or to purify. In the separate system the water is saved from pollution, and, flowing by gravitation, not only feeds our rivers and streams, but increases our water supply, which is running short. In the combined system the water is unnecessarily wasted, and our rivers and streams are starved. In the one case, the water being of great value, is saved and can be utilized for various purposes, besides being "a thing of beauty" and "a joy for ever"; in the other, being polluted, it is lost to the community, and the sewage, greatly increased in bulk, is disgusting and a nuisance.

Such is a summary of the combined system of drainage. Can a system like this last? Impossible! The idea is absurd. Very extraordinary things may happen, but the British taxpayer will never consent to pay large sums of money annually for pumping and purifying water that ought never to have been polluted, and which ought to be at once conveyed to the river by gravitation.

Taking the country through, hundreds of thousands of pounds have been spent in the first cost of works for the combined system of drainage; but, notwithstanding this—looking at the cost and difficulty of treating and disposing of enormous volumes of sewage which has no commercial value; looking at the pollution of streams and also at the scarcity of water, and at all the facts of the case—

the author concludes that—as in the "Railway Battle of the Gauges," notwithstanding the original outlay, and notwithstanding the cost of the alteration, the broad has been altered to the narrow gauge—so, in the matter of sewage, sanitary authorities, who have got a combined system, will be compelled to keep the rainfall free from sewage, and that, subject to various modifications, the separate system of drainage will be universally adopted. And the author predicts that even London, which has spent its thousands upon the combined system, and is spending thousands to maintain it, will even yet be compelled to modify its works and adopt the separate system.

If this were done, the capacity of the sewers for removing excrementitious matter, and foul and waste water from the district would be greatly increased.

At the present moment, there is a difficulty with regard to the drainage of several towns situate on the banks of the Thames. Some of these towns are intimately connected with the metropolis for drainage purpose; they have been heavily taxed for drainage works executed within the metropolitan area, and have a right of drainage into the metropolitan system, but in reply to applications for that purpose, they are met with the remark, "Oh, we cannot take you in, our sewers are not large

enough." Now, such a remark may be perfectly correct if it means that the sewers are not large enough to take in the rain water and the sewage also, but it is not correct to say that the sewers are not sufficiently large to take in the sewage of these towns. The western sewers, for instance, were constructed for this very purpose; if not, why were they constructed so large? First-class sewers to drain streets are ridiculous. The sewage for the western district at the present time is so small in quantity that if the streams were excluded the pumps would have comparatively nothing to do. If the agricultural drainage and streams were allowed to flow along their natural channels to the river it would reduce the expense of pumping, and the carrying capacity of the sewers for removing sewage proper would be so greatly increased, that the district of the Lower Thames Valley Joint Drainage Board might be connected with the Metropolis for drainage purposes to the great benefit of all concerned.

CHAPTER V.

A PROPOSED METHOD OF SEWAGE DISPOSAL FOR THE METROPOLIS, NORTH OF THE THAMES.

The Present Works a failure as regards the disposal of the Sewage—The effect of discharging Sewage into the River—The Nuisance from the sewage—Shoals are formed—It is desirable to reduce the quantity—UTILIZATION SCHEME—The author would cut off the Western District and make three separate Sewage Districts—PRECIPITATION SCHEME—The Sewage to be Treated with Lime at the Present Works—Depositing Tanks to be Constructed on the Marshes—The Sludge to be Utilized in the Manufacture of Bricks.

HE disposal of the sewage of London has always been a matter of difficulty, and this difficulty has not been removed by the present system of drainage. The brick work has been executed in the very best manner and the pumping machinery is a wonderful specimen of mechanical skill, but still so far as regards the disposal of the sewage, the works are insufficient and it is at present disposed of by discharging it into the river, sludge and all, without any treatment whatever. The effect of this is that the river is polluted to an alarming extent, shoals are formed which impede the navigation, and the sewage filth is constantly being cast upon the river banks. The old plan was to store

the sewage in cesspools, constructed in yards and gardens and sometimes under houses, it was next turned into the Thames, and it is by the present system moved on and turned into the river lower down. The nuisance is recurring. It has been removed but not abated, it will therefore crop up again and again unless something is done, and this is a grave sanitary defect.

In order to dispose of the sewage economically it must be brought into a small compass; as it is we have to pay for purifying, conveying, pumping and storing it, at so much per million gallons, and every gallon of water with which the sewage is diluted adds to the cost, besides that, the clean water is lost to the community.

There is no doubt but it would have been far better, in the first instance, to have divided the metropolis into separate sewage districts; for if this had been done, the quantity of sewage in each could easily have been treated and purified. There was no necessity to bring all the sewage to one point, and it was a great mistake to do so, as it is so much more difficult to treat on account of its bulk.

Utilization Scheme.

For a system of utilization the author would reopen the natural water courses and modify the

existing system so as to divert all streams from the sewers; cut off the unnatural connection between the Eastern and Western districts, and deal with the Western sewage in its own district. If that be impracticable now on account of the building that has been going on; he would pump it into the high or mid-level sewer, and if these be not of sufficient capacity he would construct a new line of sewer along Buckingham Palace Road, Victoria Street, Whitehall, St. Martins' Lane, Hart Street, Theobald Road, Old Street and Hackney Road, &c. He would make three separate sewage districts, for the high-level, middle-level, and low-level sewers the high-level sewage to be diverted and disposed of by gravitation in the direction of Leyton; the middle-level sewage to be dealt with at a lower level than the last; the low level and Western sewage to be pumped into Essex in the direction of Barking, and he would construct works to clarify the sewage with lime and afterwards purify it by passing it through the soil, as described in part II of this work.

Precipitation Scheme.

For a system of clarification only, the author would utilize the present works for the treatment of the sewage, and construct depositing tanks upon the marshes beyond Barking Creek.

For treating the sewage he would adopt the lime process, because it is the cheapest and most efficient process that has yet been employed Lime would not be injurious to the river, for it is always present in its waters, and as there are lime-kilns on the banks of the Thames, not far distant from the present outfalls, it can easily be obtained. At Birmingham the sewage, amounting to 8 million gallons per day, and at Leeds the sewage, amounting to 12 million gallons per day, is treated at each place most efficiently by the lime process.

Without going into the details of precipitation, which will be found in another part of this work, the author would separate the drift by catch-pits, remove it from the works and shoot it to waste, until some use can be found for it. The night soil and coarse floating matter he would remove by screening, and sell it for manure. For this purpose he would remove it in barges or by railway, and establish depots for the sale of it, or take land to utilize it. Part of the fine sewage mud he would pump into brick-fields, and utilize it in making stock bricks; the remainder he would pump on to the marshes to raise the ground, and afterwards utilize the ground for market gardens, or he would let the mud lay until the organic matter had rotted, when it may be removed and utilized for dressing gardens or fields. If there be no use for it, he would bank it round and

raise it to a height of 50 feet if necessary. With these means of disposal there is no pretence for saying that the sewage cannot be dealt with by precipitation on account of the quantity of sludge, for the whole of it can be disposed of immediately without loss, supposing there is no demand for it, but there is a probability of some of it being utilized at a profit. Taking the quantity of sewage at 60 millions of gallons per day, the works would only require to be about five times as large as those at Leeds.

CHAPTER VI.

THE AUTHOR'S NEW METHOD OF UTILIZING SEWAGE SLUDGE.

Sludge accumulation—Opinions of Commissioners, &c., as to its Value —Drift—Organic Matter—Sludge or Malm—The Cement Process—Invention of the Stock Brick Making Process—Importance of the Invention—Opinions of Eminent Engineers as to the Sludge Difficulty —A Profit from Sewage Sludge—A few Remarks about Brick-making

THE question of sewage purification has been perfectly solved so far as the liquid is concerned, and there is now no difficulty whatever in obtaining an effluent fit to turn into any stream or river, the water from which is not used for drinking purposes, if the sanitary authorities will only take the trouble and go to the expense.

Hitherto there has been considerable difficulty in disposing of the solids, which are extracted from the sewage for the purpose of purification, the consequence is that large quantities have accumulated at various sewage works. At Leicester there is an accumulation of about 30,000 cubic yards of this refuse. At Leeds things are no better and a large quantity of sewage mud having accumulated, and the land available for its reception being all occupied, men were recently employed to dig it

out of the pits and stack it on the sides, but still this did not prevent its accumulation. At Birmingham, the sludge is disposed of by digging it into the ground at a cost of about £1,300 per annum, for labour only, besides the cost of land which is a very considerable item, 90 acres being required every year for this purpose and if this process goes on for any length of time the surface will become one mass of sewage filth. It was at first supposed that it would rot away in two years so that the land could be used over and over again, but this is found not to be the case.

In the early stage of the sewage question sewage mud was thought to be a valuable manure and a very influential company having obtained a grant of the sewage of Leicester for 30 years, carried out their process on a large scale, but it was not a success. The manure which was estimated to be worth two guineas per ton was found to be worthless and the company were obliged to give up their magnificent works to the Corporation, to be let off their bargain. Since then other companies have been formed for the purpose of utilizing sewage sludge as a manure, by using fertilizing elements for precipitation, but they have not been commercially successful, for the manure was found to be of less value than the chemicals, which had been used for its precipitation. Other

companies have endeavoured to fortify the sludge with fertilizing chemicals, and so make it a valuable manure, but they also have been unsuccessful: sewage manures being unmarketable on account of their low value in proportion to their bulk.

Various Royal Commissions have been issued for the purpose of eliciting information as to the value of sewage sludge and the most eminent scientific men have given evidence. The following quotations from these sources are worthy of the serious consideration of sanitary authorities:—

"Comparatively few farms are so situated that they can afford the expense of carting semi-dried sewage sludge, containing from 60 to 70 per cent. of moisture from the works to their fields. The refusal to accept such sludge as a gift in not a few instances, rather shows sound discrimination than ignorance on the part of the farmers."—*Voelcker's Report, Town Sewage*, 1876.

"It appears further that the sludge in a manurial point of view is of a low and uncertain commercial value, and the cost of its conversion into a valuable manure will preclude the attainment of any adequate return on the outlay and working expenses connected therewith, and that means must therefore be used for getting rid of it without reference to possible profit."—*Society of Arts Conference, June*, 1876.

"It would appear that to learn the lesson that money cannot be made out of sewage sludge is very difficult, as over and over again it has been proved that there is no commercial value in it. The Leicester works proved this many years since, and every independent chemist of known repute has stated the fact when called upon to analyse sewage mud. Neither is this mud capable of being fortified by an admixture of chemicals, which will give it a paying commercial value. * * * * Neither the lime process nor any other existing method of precipitating sewage is likely to be commercially advantageous to those who engage in it. We consider that this is, however, not the light in which the matter should be viewed. The great problem is to get rid of sewage advantageously, to agriculture it may be; if not, at the least expense to the community at large."—*Report of Royal Commission, Town Sewage*, 1876.

Notwithstanding these difficulties, as sanitary authorities are now compelled by the Public Health Act, 1875, to free their sewage from "all excrementitious or other foul or noxious matter before it is discharged into any natural stream or watercourse," precipitation is being more and more resorted to.

The author, therefore, puts forward the following process for dealing with sewage mud and the

solids from town sewage, believing that it will meet the want which has so long been felt, better than any process that has heretofore been proposed, and if properly taken up and fairly worked with the requisite skill and appliances, it cannot fail of success.

The works proposed by the author in another part under the head of Sewage Treatment, would naturally divide the solids from the sewage of a Town, where the combined system of drainage has been adopted, into three sorts—Drift—Organic Matter—Sludge or Malm,—and as they possess different properties, he proposes to keep them separate and deal with them in three different ways, which will give three chances of disposal instead of one, and the separated materials will not only be more easy to deal with, but more valuable than when they are mixed together.

Drift.

The Drift, consisting chiefly of the coarse particles washed from the roads and streets, may, according to circumstances, be shot to waste, or washed and used for making foot paths, bottoms of roads, or similar purposes, and in some cases it may be ground and used for making mortar.

Organic Matter.

The coarse organic matter consisting of the

insoluble parts of the sewage, including night soil, paper, rags, and the fibrous and floating matter of trade refuse from the various manufactories, which is separated by the screening process, may be removed to agricultural districts, and laid in heaps to rot, along with other manure, until required for use by the farmer; or it may be decomposed and fortified with chemicals, and then dried by pressing, or in any other convenient manner, and utilized as a low class of artificial manure.

Sewage Sludge or Malm.

The term sewage sludge in this place is not intended to include the drift nor the coarse organic matter just described, but it refers solely to the finely divided insoluble particles which are precipitated by lime, after the coarse organic matter and drift have been removed. It consists of lime used for precipitation, chalk precipitated from the water, alumina from the washing of clay lands, silica from the washing of roads, and various sorts of mineral matter. As stated elsewhere, it requires $1\frac{1}{2}$ yards of lime for the treatment of $1\frac{1}{4}$ million gallons of sewage, and the precipitate is equal to 45 tons of thin sludge, containing 90 per cent. of water, and it is found that when the water supply is derived from calcareous strata, the chalk in the

sludge is equal to about four times the quantity of lime used for precipitation.

Sludge is very retentive of the water with which it is mixed, and by itself will not readily dry; if dug into the ground it does not rot but clings together, and as we have seen, it possesses no value as a manure, but partakes very much of the character of the malm or washed clay and chalk, which is used in the neighbourhood of London in the manufacture of stock bricks, and it was from a knowledge of these and other facts that the author arrived at the conclusion to utilize it in that way. He is aware that it has been used in the manufacture of cement, but if you can make cement from sewage sludge you can also make stock bricks and if the cement process be successful the brick-making process will be much more so; all the advantages are on the side of the brick-making, and what is good in the former process is also good in the latter. Portland Cement is made with 65 per cent. of chalk and 35 per cent. of clay, and bricks are made with lime and clay in the following proportions:—Malms, 33 per cent. chalk, 67 per cent. clay; Washed Stocks, 22 per cent. chalk, 78 per cent. clay; Common Stocks, 11 per cent. chalk, 89 per cent. clay. The organic matter in both cases is consumed, and there is a complete chemical change. The brick is semi-vitreous and if the

burning is continued it runs to slag, the substance so formed being similar to blue bottle glass.

In order to make good cement the mixture of lime and clay must be combined in pretty accurate proportions, but sewage sludge is a most uncertain mixture and the quantity of lime in it being subject to considerable fluctuation, renders the process of cement making uncertain; and the material must be dried. There is not this difficulty with the brick-making process, because the quantity of lime may vary from 11 to 33 per cent. and yet the bricks will be equally good; it is only a question of sorting them after they are made. Then as to the moisture in the sludge it is costly and difficult to evaporate in order to make cement, but to make bricks it can be utilized to temper the clay, as a considerable quantity of moisture is required for that purpose.

The above remarks are made with a view to comparison and not in any way to disparage the cement process. But every step taken by the author confirms him in the belief that there is a great future for the brick-making process in utilizing sewage sludge, because the proportions do not require to be accurate in order to obtain a good result; because it surmounts the difficulty of drying the sludge, because no skilled labour is required to carry on the process beyond what is to be found in

any brick-field and because it is most generally applicable.

Brick Making.

The following extract from the minutes of proceedings of the Institution of Civil Engineers, Vol. 61, issued August, 1880, so well describes this process that it is given at length.

"Mr. E. Monson exhibited various samples of bricks made from sewage sludge. Being one of the engineers who had received instructions to prepare plans for disposing of the sewage of the Lower Thames Valley, his scheme, as well as those of other engineers, had been reduced to a common standard, and it was debited with the sum of £48,000 as the capitalised cost of treating the sewage with lime, previous to its being passed through the soil by intermittent filtration. This led Mr. Monson to consider how he could utilize the sludge and reduce the annual cost of treatment. Almost adjoining his residence there were a number of brick-fields, and in order to make stock bricks it was necessary to mix chalk with the clay. This chalk was brought from a distance at great expense, and was ground with water and mixed with the clay. For the better class of bricks, the cost of the chalk and grinding was 6s. per 1,000; for the common stock bricks the cost was 2s. per 1,000. The semi-liquid mass of

chalk and clay was called malm. It occurred to him that the sewage mud precipitated with lime was similar to this mixture of clay and chalk, and that it might be utilized as a substitute for malm in the manufacture of stock bricks. He accordingly procured some sewage sludge, mixed it with clay, and made it into bricks, some of which had been burnt in a kiln, and some in a clamp. The kiln-burnt bricks were hollow and husky, because the materials had not been properly mixed, and because they had not been properly put together by clot moulding before making. The clamp-burnt bricks were better, but they were all burnt to rough stocks except one brick, and that was a fine colour, though from the faulty moulding it lacked density. He continued the experiments, and had succeeded beyond his most sanguine expectations; at every stage he improved on the last. The colour of the bricks did not depend so much upon the clay as the way in which the bricks were burnt. If properly burnt in a clamp they would be yellow stocks; if burnt in a Scotch kiln, they would be red; if the heat was increased and the bricks close bolted, they would frequently be white or grey; and if burnt in a kiln or oven, such as was used for burning Staffordshire blue bricks, they would be blue. The yellow colour and the white were owing to an intense heat, the admixture of chalk, and the bricks being close bolted

for burning. The red colour was due to the bricks being burnt at a low heat with a free supply of air; the blue, to the bricks being burnt with an intense heat, and deprived of air. If sewage sludge was made into stock bricks the materials were changed; the lime in the sludge combined with the silica and alumina in the brick earth forming a silicate of lime and alumina, and if properly burnt was converted into a rough sort of glass. The organic matter was completely decomposed. The bricks, being burnt with ashes, would in some towns effect a saving of 8s. per 1,000 bricks; and the ashes, which in many towns were shot to waste, could be thus utilized and profitably disposed of. The discovery in London a century ago, that town ashes could be utilized for burning bricks in clamps was a most important event. Once the clamp was lighted, it continued to burn without attention, except to shelter it from the wind, and the bricks remained in the clamp until they were required. In utilizing sewage sludge in the manufacture of bricks much depended upon having the materials intimately mixed and well put together, and this was what an ordinary workman would seldom do if the bricks were made by hand, but there was no difficulty if they were made by machinery. The machine-made red bricks, consisting of two parts of Leeds sewage sludge and one part of shale, were manufactured at Mr. Wray's

brickworks, Leeds. The sludge, when nearly dry, was mixed with the shale, and tipped into a perforated pan, the bricks being manufactured without any further handling, except by a boy for additional pressing. One thousand two hundred bricks were made in this way in two hours from the time of commencing. They were burnt in a close kiln, which had a steam flue at the top, connected with a tall shaft. When the steam was driven off the steam port was closed, and a connection with the shaft was opened from the bottom of the kiln."

"Amongst the sanitary appliances, we noticed some model samples of bricks made from the sewage sludge of Birmingham, Leicester, Windsor, and Ealing. The patentee is Mr. Monson, C.E., of Acton, W., and he claims for his invention that it is not only an efficient but a profitable method of disposing of sewage sludge and town ashes. The bricks were of various colours, exceedingly well made, perfectly sound, and adapted to clamp and kiln burning. Mr. Monson's process completely removes all difficulty in disposing of sewage sludge; and as it turns to profitable account what is now a source of vexation and expense to sanitary authorities, we shall probably soon hear of its extensive adoption; and we should particularly commend it to the attention of the Metropolitan Board of Works, as one means of utilising the sewage sludge which is now

daily poured into the Thames."—*Extract from the "Sanitary Register," 6th June*, 1879.

At Birmingham, 53,000 bricks were made and sold at market price, and it was found that a superior white brick could be made by adding one-eighth of sewage sludge to marl, which ordinarily burns red. At Leicester, bricks have been burnt in kilns and clamp, and the result shows, that with proper appliances the process will be a great success.

The importance of this invention may be gathered from the discussions upon the sewage question which have taken place at the Institution of Civil Engineers, and the following are some of the opinions then expressed.

"Apart, however, from this financial objection there is a formidable practical difficulty attaching to the use of these processes [precipitation] which up to the present time has proved an almost fatal bar to their efficient operation, namely, the difficulty of dealing with the enormous quantity of sludge developed by the employment of precipitants."—*Mr. N. Bazalgette.*

"The chemical processes, hitherto applied to the purification of sewage, depended essentially upon the production of certain solid compounds within the body of the sewage, which solid compounds carried down with them the suspended matter of the sewage, and a certain small proportion, varying with the

quantity of the solid so deposited, of the polluting matters in solution. The principal solid matters thus produced within the body of the sewage were carbonate of lime, alumina, oxide of iron, and carbonate of magnesia. There was also the phosphate of alumina, which however, did not differ in its character from the other materials. These chemicals were nearly identical with the chief constituents of the earth's surface."—*Dr. Frankland, Minutes of Proceedings of Civil Engineers, Vol.* 48.

"In conclusion, it ought not to be supposed that intermittent downward filtration got rid of the most difficult portions of sewage, namely, the sludge."—*Mr. Hy. Law.*

"The information obtained during the last few months showed distinctly that the sewage question resolved itself into the difficulty of the disposing of the solid matters in suspension. The difficulty of treating the sludge by chemical processes was notorious. In irrigation and filtration it was the solid matter in suspension that fouled the carriers and the land and blocked up the pores of the filtering material."—*Mr. Shelford.*

"The great difficulty attending the chemical processes for treating sewage was that in such treatment an enormous quantity of semi-liquid sludge was produced. When removed from the tanks this sludge contained 90 per cent. of water, and it was the

separation of the solid material from this water which constituted the difficulty. The removal of the water of the sludge, either by drying or by any plan of filtering, was attended with both trouble and expense. The production of useful manure out of this sludge at a moderate cost, was, he believed, out of the question."—*Mr. T. W. Keates.*

"The aim of the chemist should be to provide a cheap precipitant which would keep down as much as possible the bulk of the precipitate. The great difficulty in connection with all the tank processes, was the disposal of the sludge, and the less the precipitating agent itself added to the quantity of this the better. Such a process as that, of digging in the immense quantity of sludge produced by the lime process at Birmingham, was unlikely to be of long duration."—*Mr. James Mansergh.*

"The greatest difficulty in dealing with raw sewage next to its bulk and highly diluted condition was caused by the slimy organic matter which raw sewage contained in a state of suspension. These suspended matters, and not the matters in solution, were the cause of most soils becoming sewage sodden. Remove the suspended matters, and half the difficulty of the disposal of sewage would be solved. Unfortunately the removal of the matters in suspension entailed expenses."—*Dr. Voelcker.*

There are difficulties in introducing this or any other process.

FIRSTLY. Because so many things have been tried and failed.

SECONDLY. Because sanitary authorities are waiting for some miraculous invention that shall supplant all others and enable them to dispose of their refuse without trouble or expense.

THIRDLY. Because there are vested interests to contend with. Brickmakers are averse to an additional quantity of bricks being made, and the farmers, superintendents or managers of sewage works, as a rule, wish things to remain as they are.

If this process be taken up by the sanitary authorities themselves, and fairly worked, they will make a profit where they now sustain a loss; they will get rid of the nuisance from the present accumulations and save the cost of ground for its storage; and they will find that they are not only able to utilize the sewage mud and town ashes in the manufacture of bricks, but also the clay and marl from the various excavations for laying pipes and sewers in their district, which is now shot to waste; and as good stock bricks are superior to all others for engineering purposes, many of the bricks made by the authority can be used in their own works to the great advantage of the ratepayers in point of economy, and the making of bricks must not be regarded from a brickmaker's point of view, because its primary object is to utilize and

dispose of sewage mud; a product which at present has not a marketable value.

The burning of bricks in clamps in the neighbourhood of London, effects a saving of about 6/- per thousand as compared with kiln burning, and on the Northern side of London where chalk is difficult to obtain, it is estimated that the use of sewage sludge instead of chalk for making malm bricks, provided the sludge were delivered direct into the brick field, would effect a saving of 6/- per 1,000; for washed stocks, 4/- per 1,000; for common stocks, 2/- per 1,000.

Bricks are made from a variety of materials according to the district, the principal of which are mild clay, galt, marl, shale and blue bind. They are mostly burnt in kilns, but the London stocks are invariably burnt in clamps.

Sewage sludge can be utilized in the manufacture of every kind of brick, but as it is best suited for the manufacture of stock bricks, that process will be described more in detail.

Stock bricks are principally made in the neighbourhood of London, and the process was invented for the purpose of utilizing the refuse of dust bins many years ago, but it is not known when it was invented nor by whom. The brick earth is dug in winter turned over and exposed to the weather; a mixture of clay and chalk which

has been reduced to slurry in a wash mill, is run upon it by means of shoots. The quantity depends upon the quality of the brick it is intended to make, only a small quantity being required for common stocks. The whole of the clay and chalk used for making the best bricks, which are called malms, should be washed. Fine ash in the proportion of about three inches in depth of ash to one foot in depth of prepared earth, is mixed with it to burn the bricks and to keep them from shrinking whilst drying.

"The object of adding chalk to the clay is two-fold. In the first place it acts mechanically in diminishing the contraction of the raw brick before burning, and in the second place it acts as a flux during the burning, combining with the silica of the clay, so that a well-burnt London brick may be described as a silicate of lime and alumina, and therefore differs greatly from an ordinary red, kiln burnt brick, made of pure clay without lime or alkaline matter, the silica and alumina of the brick-earth being in the latter case merely in mechanical and not in chemical combination."—*Dobson Brick and Tile Making.*

For the utilization of sludge the materials may be prepared by taking the brick earth from bank; adding the sludge and ashes and grinding the whole in a nine feet solid bottom pan, so that lumps